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TACIUK PROCESSOR FOR TREATMENT OF OIL CONTAMINATED WASTES

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ABSTRACT

The Taciuk Processor has been developed primarily for direct thermal processing of oil sands and oil shales to produce a partially upgraded oil. It is also capable of handling and treating oily waste solids, sludges and liquids. Recent test work has studied and demonstrated use of the Processor plant and technology for clean-up treatment of these materials. The plant produces separate water products, thermally cracked oil products and a combusted solids residue. This residue is environmentally acceptable for permanent disposal. A prototype plant has been designed for clean-up treatment of the wastes associated with a decommissioned refinery site in Canada.

This paper presents the Taciuk Processor technology and describes the evaluation and test work carried out to date on oil-contaminated wastes. An approximate comparison, for a 15 ton/hour portable Processor plant versus an equivalent incinerator plant, is included.

INTRODUCTION

UMATAC Industrial Processes, a Division of UMA Engineering Ltd., in cooperation with the Alberta Oil Sands Technology and Research Authority (AOSTRA), has developed a direct thermal process which simultaneously cracks hydrocarbons present in oil sand feed, extracts and recovers the liquid oil fractions as a hot vapor, recovers the gas fractions and burns coke deposited on the host sand to provide the major heat requirements of the process. Initial development started in 1975 with batch-scale testing. In 1977, development agreements were signed with the Alberta Oil Sands Technology and Research Authority (AOSTRA) whereby a pilot plant was constructed and operated in Calgary (Phase A). This plant was

completed in early 1978, initially operated as a coker during 1978 using a reduced crude oil feedstock for initial testing simplicity, then operated during 1979 and 1980 on various grades of oil sand feeds. Process and operating data provided encouraging results for plant performance and proved the basic concepts.

During the period 1981-1982 (Phase B), further test work on oil sands, varying in bitumen content from 6% to 14%, was successfully completed.

During the period 1983-1984 (Phase I), efforts were concentrated on scale-up definition, demonstration and commercial Processor design, and on capital and operating cost comparisons relative to oil sands processes now in commercial use.

In 1984, a proposal, including definitive design and cost estimates for a 90 tonne/hour Demonstration Project, was completed and submitted to AOSTRA.

During the period 1985-1986, UMATAC continued with the demonstration project planning, general design evolution, and scale-up definitions relating to the Taciuk Processor including its associated systems. In 1986, with the rapid decline in world oil prices discouraging oil sand development, UMATAC concentrated part of its efforts on other uses of the Processor technology. A successful test program on Australian oil shales was completed in late 1986. In addition to this program, several series of batch tests were carried out on various waste or reject feedstocks such as crude oil tank cleanings, heavy oil reject material, refinery API separator emulsions, and oil contaminated materials from waste dumps and clean-up operations.

Solid products from these tests exhibited excellent leachate characteristics which were well within environmental requirements so that solids which had been passed through the Processor could be de-listed and used for landfill.

PROCESS GENERAL DESCRIPTION

The Taciuk Processor system consists of several collection, treating and handling systems connected to the Processor unit. The major systems, flows and products are illustrated on enclosed Flow Diagram A, and consist of the following.

1. Feed Systems comprising a combination of hoppers for feeds containing mostly solid materials such as sand and gravel, a hopper for circulating sand charge addition where liquid feed is processed, and tanks containing liquid or slurry feedstocks.

2. Low Temperature Steam System which is used to collect all steam, light hydrocarbons and inert gases produced in the feed preheating zone. This effluent can be directly discharged or condensed and processed for oil recovery if light oils are present in this stream.

3. Hydrocarbon Vapor System which is used to collect all vapors produced in the reaction zone. These hot vapors are products of thermal cracking and exit at approximately 1000°F. This flow is processed through cyclones, fractionator, condensers, heat exchangers, gas compressors and separators to produce water, oil and gas by-products.

4. Flue Gas System which is used to collect all combustion gases and leakage gases from the Processor and its systems. These gases are cooled, treated for particulate removal, then treated for chemical removal of other impurities, such as sulfur dioxide, prior to release to the atmosphere.

5. Combustion Air and Auxiliary Burner Systems for coke and process fuel combustion are designed to suit the particular feed characteristics. Fuel derived from the thermal cracking, in the form of coke and C_4 minus off-gases, is used for primary heat requirements and can be supplemented by combustion of a portion of the oil product in the auxiliary burners if this is required.

6. Solid Discharge Cooling and Handling Systems to provide final cooling, mixing with water to control dust during handling, and conveyors to carry the discharge to storage piles.

7. Other Product Storage and Handling Systems including storage tanks, emergency flare stack, nitrogen blanketing and miscellaneous reagent systems required for specific feedstocks.

8. Heat Exchange Systems for oil vapor condensing, flue gas cooling, tailings cooling, combustion air preheat and for satellite steam generation can be incorporated on the various flow streams depending on individual plant requirements.

PROCESSOR DESCRIPTION

The heart of this processing concept is the Taciuk Processor. It consists of a single, horizontal, rotating vessel containing individual compartments that perform the processing steps required to recover and separate various product streams. (Reference Flow Diagram B.)

In the oil sands treatment mode, as-mined oil sand feed is introduced into the preheating section of the Processor where connate water is evaporated as steam, frozen material is ablated, oversize material is removed and solids are heated by heat exchange with the hot, outgoing tailings sand. The preheated sands are then transported into the reaction zone where they are mixed with hot, combusted sand from the combustion zone. The resulting temperature is adequate to thermally crack the hydrocarbons, yielding a vapor stream containing the cracking reaction gases and liquids (in vapor form), and leaving a coke-residue coating on the sand. The hydrocarbon vapor stream leaving the Processor is passed through cyclones to remove fine solids, then processed through a fractionating tower where liquid fractions may be separated for further processing. Fractionator off-gases are further cooled to condense light ends and water, then passed to a central gas processing plant to recover additional light ends. A heavy bottoms oil cut from the fractionating tower can be recycled back to the Processor reaction chamber or used as supplemental process fuel. The product oils can be pumped to downstream, or remotely located, hydrotreating facilities or sold as fuel.

The coke-coated sand leaving the reaction zone discharges into the combustion zone. In this zone, preheated air is injected to burn most of the coke to provide heat for the Processor. Auxiliary burners are available to provide heat for startup, trim control and emergency conditions. The hot sand from the combustion zone passes through a recycling arrangement that ensures an adequate supply of hot sand to the reaction zone, while allowing net sand to move into the outer heat exchange compartment. As the net sand flows through the heat exchange zone, it is cooled by giving up heat to the incoming sand feed. The partially cooled tailings sand is removed from the Processor, further cooled and wetted by water addition, then transported by conveyors to a tailings area.

Combustion gases leaving the Processor flow through cyclones to reduce the fine solids, then pass through scrubbers that remove most of the remaining fine solids and chemically removes most of the sulfur dioxide produced by the combustion of coke. The wet scrubber liquid can be used as a cooling medium for the tailings sand.

For treatment of waste materials, the same concept as described above is used except that the heat exchange zone/reaction zone configuration can be adjusted in several stages depending on the relative quantity of solids, water and hydrocarbons in the feed. With feeds containing mostly solid particles (more than 70%), the primary reactor and primary recycle are used (full heat exchange area). As the quantity of solids in the feed decreases (30 to 70% solids content), the secondary sand recycle can be used to reduce heat exchange capacity and increase reaction zone capacity. When handling dilute feeds containing less than 30% solids, the tertiary sand recycle is also utilized to further increase reactor capacity. This series of adjustable sand recycle points provide the Processor with the fle-ibility to economically process a complete range of feeds from liquid emulsions and contaminated ·ils, to contaminated solids. With complete recycling of combusted sand, the Processor becomes a thermal cracker or coker, and can be used for processing heavy oils, bitumens and other liquid materials. In this mode, the excess coke and off-gas can be burned and heat used to produce high pressure steam for oil well stimulation.

PROCESSOR USE FOR WASTE CLEANUP

As described earlier, the Taciuk Processor and its associated systems can be readily adapted to handle a range of feedstocks varying in any combination of 0 to 100% oil content, water content and solid particle content. In addition to this, oversize rocks and other tramp material can be accepted as feed then rejected by an oversize screening system that can be incorporated in the inner heat exchange zone.

All hydrocarbons in the feed are subjected to thermal cracking temperatures in the reaction zone. Since this zone contains no oxygen, the oil products can be collected without combustion. The coked solids leaving the reaction zone contain only extremely faint traces of leachable hydrocarbons (0 to 5 ppm total). Once this coked sand passes through the combustion zone, no trace of hydrocarbons is detectable.

UMATAC's years of research, testing and development of the Processor for oil sands had indicated that the solids tailings produced could pass stringent environmental leachate tests. This was verified by extensive testing of all Processor effluents to establish the type and quantity of impurities present in these streams. A complete series of tests on feedstocks with the following approximate range of characteristics, have been carried out by UMATAC.

WASTE FEED CONSTITUENT ANALYSIS (WT%)

	Contaminated Soils	API Separator Area Sludges	Alkylation Unit Sludge
Water Content	26%	55%	35%
Oil Content	3-5%	20%	50%
Solids Content	70%	25%	10%
Sulfur Content	0.2%	0.5-2%	5%
TOTAL	100%	100%	100%

The sludges contained extremely fine solids in the form of clays, fine silica, drilling muds and metal-bearing fine materials. These fines were trapped by the coke after the thermal cracking so that the oil and water by-products contained only trace amounts of solids and metals.

TYPICAL ANALYTICAL TEST RESULTS FOR API SEPARATOR AREA SLUDGES

Samples of API separator area sludges were obtained from a Montreal area refinery and were subjected to a complete series of thermal cracking (pyrolysis) tests and combustion tests. A representative blend of the three major sludge sources was used for the final series of "blend" tests. The blend was made up as follows.

	WT%
API Separator Bottoms	67%
DAF Float Emulsion	20%
Slop Oil Emulsion	13%
TOTAL	100

This blend was an emulsified sludge containing a light oil (25 to 35° API range), mixed with fine solids of the following size distribution.

Particle Size (mm)	Cumulative Percent Passing
12.7	100%
6.3	100%
2.4	99.9%
0.8	99.5%
0.6	99%
0.3	98%

0.15	85%
0.105	74%
0.07	64%
0.044	51%

The thermal cracking product distribution was as follows (on a weight basis).

C_4- Off-Gas	3.5%
Coke	13%
C_5+ Oil Product	83.5%

The product oil had an API gravity of 37, an RCR of 0.16%, and a BSW of 0.024%.

Enclosed Table #1 is a summary of the constituent analyses results for the blend feed, product oil, condensed product water, product solid residue and the Leachate tests carried out on the combusted product solids residue. The Leachate test procedure followed was the standard United States EPA procedure as described in the Federal Register, Volume 51, No.114, pages 21685-21691, dated June 13, 1986.

Analysis of results contained in this table leads to the following conclusions.

1. The leachate liquid contains only 1.6 ppm of total oil and greases, only 0.003 ppm of phenols, and very minor quantities of metals. Priority PAH's and phenols were not detected.

2. The produced oil is probably acceptable for recycling as refinery feedstock.

3. The produced water can be processed by conventional clarification, filtration, or bacteriological treatment, to produce an environmentally acceptable effluent.

4. The solids can be directly "delisted" and used for general landfill.

UMATAC also carried out four series of sampling and analyses tests on flue gas effluents before and after wet scrubbing. These samples were obtained during a pilot plant test run on "contaminated soils" as identified in the waste feed constituent analysis table. Test results indicate that a single-stage, direct impingement water scrubber can produce environmentally acceptable gases for atmospheric dispersion.

TACIUK PROCESSOR PLANT VERSUS INCINERATOR PLANT

To the best of UMATAC's knowledge, all existing thermal waste treatment facilities use some form of heat addition and total combustion of combustible materials present in the waste feed materials. This usually means that all feed materials, including water and fine solids present in the feedstocks, are passed through the incinerator stages and are removed in the final flue gas cleaning and scrubbing equipment. Treatment of waste materials containing a high percentage of water and oil products require extremely large downstream combustion and gas handling facilities with release of large quantities of heat that is usually not recovered in a transportable-type facility.

Any combustion process, including incineration, requires specific quantities of combustion air depending on the hydrogen, carbon and sulfur content of the feed. Enclosed Figure #1 gives an approximation of the stoichiometric and 30% excess air values for fuel combustion. A value of 18 lbs. air per pound of fuel burned is used as a common basis for comparing the Processor plant versus an incinerator plant.

Since incinerators oxidize all of the combustible materials in the feed, there is generally a surplus of heat developed. In large integrated incinerator facilities, this excess heat can be recovered by heat exchange to produce steam or other forms of usable energy. In a portable plant, heat utilization becomes much more complex and costly so, for comparison purposes, we have assumed that cooling air is added to the final stages of the incinerator to cool the flue gas down to a maximum temperature of 1800°F, and that water is added to further cool the flue gases down to 375°F, then to below 200°F for wet scrubbing. The final incinerator flue gas flow can be reduced somewhat by finned-tube cooling or by adding water instead of air for the combustion stage cooling. Enclosed Figure #2 illustrates the relative cooling capacity of water/steam, air and silica sand.

The Taciuk Processor system has the ability to evaporate water as a separate flow at temperatures of 250 to 300°F, then condense it as a separate product. It can also thermally crack and collect a light product oil and a fuel gas at temperatures of 950 to 1100°F. With other flexibilities as described earlier, the Processor is able to stage-treat a full range of waste materials in an efficient and economic manner as well as recovering an oil product that can be recycled as refinery feed or sold as fuel oil.

Table #2 provides an approximate data comparison for a 15 ton/hour Processor plant and an equal sized incinerator plant that might be used to process a liquid sludge feed containing 50% hydrocarbons. This incinerator plant would be rated at 270 million BTU per hour

and we understand that the largest transportable incinerator plants constructed to date are in the range of 40 to 70 million BTU/hour.

Key data extracted from Table #2 is summarized as follows:

	TACIUK PROCESSOR	INCINERATOR
Processor Heat Developed	30 MM BTU/hr	270 MM BTU/hr
Total Flue Gas Discharged	37000 lbs/hr	635000 lbs/hr
Water Vapor in Flue Gas	5000 lbs/hr	175000 lbs/hr
Flue Gas Flow at 200°F	10500 ACFM	210000 ACFM
Condensed Water Collected	10000 lbs/hr	-0-
Product Oil Collected	11000 lbs/hr	-0-
	or 35 bbls/hr	

NOTE: The incinerator case assumes dilution air added to the combustion chamber to control temperature at 1800°F. We have assumed that, on a portable incinerator plant, extensive heat recovery for satellite purposes is not feasible, so the 1800°F flue gases are quenched down to 375°F, then to 200°F, by addition of water to the gas streams prior to scrubbing.

APPROXIMATE CAPITAL AND OPERATING COSTS

UMATAC has recently completed the design of a 15 to 20 ton per hour transportable plant which is mounted on a series of bases for easy erection, disassembly and transportation. The plant includes all tanks, hoppers, conveyors, etc., necessary for operation on solid or slurry feedstocks. A portable central-control centre, which houses all the electrical and instrumentation systems and a control room with computer monitoring and data acquisition, are included in the plant design.

The capital costs for this plant are estimated to be in the range of 7.5 to 9.5 million dollars. This estimate does not include cost of transportation from Calgary, cost of license fees, or cost of assessments for taxes, duties, etc.

The annual operating costs for this plant are estimated to be in the range of 2.5 to 3.5 million dollars per year, excluding other site-related costs, license costs and owner indirect or overhead costs.

With proper scheduled maintenance, the life of this type of plant is expected to be 15 years. On this basis, the annual costs per ton of feed can be approximated as follows.

Capital cost per ton on the following basis:

Mechanical Availability	- 80%
Utilization Factor	- 0.70
Average Feed Rate	- 15 tons/hour
Operating Life	- 15 years
Average Tons/Year	- 74,000
Capital Cost	- $9,000,000 Canadian

Capital cost per ton = $8.10.

The operating cost per ton would be approximately:

$$\frac{\$3,000,000}{74,000} = \$40.50$$

On this basis, the total direct cost for operation of a 15 ton/hour Taciuk Processor system would be in the range of 45 to 55 Canadian dollars per ton of feed. This rate/ton would be reduced by 10 to

20% for feeds containing more than 70% solids, or increased by 15 to 30% for feeds containing less than 30% solids.

A by-product of handling the high oil content sludge used in the comparison example, would be an oil product. If we assume a sale price of 15 dollars per barrel, the annual potential revenue from this stream is 74000 X 35 X 15/15 = $2,600,000 which substantially reduces the direct annual operating cost.

The total cost per ton is inversely related to lifetime tonnage processed so that, if this plant capital cost had to be recovered on a project basis (say 200,000 tons of feed), the cost would rise to 85 to 100 dollars per ton. Environmental regulations and acceptable levels of pollutants contained in the various effluents vary depending on which legislative body is responsible for the clean-up site. Meeting these requirements could substantially alter both capital and operating costs so that reclamation costs are very sensitive to site location and type of impurities present in the wastes.

TACIUK PROCESSOR ADVANTAGES AND DISADVANTAGES WHEN COMPARED TO THERMAL OXIDATION (INCINERATION)

Following is a listing of advantages for Taciuk Processor use in waste treatment applications as identified by UMATAC Industrial Processes. The comparison base is incineration involving complete thermal oxidation and destruction of combustible materials present in the feedstock.

1. The Processor plant can be constructed in transportable modules for capacities up to 20 tons/hour.

2. Water present in the feed can be evaporated at temperatures of 250 to 300°F, collected and condensed as a separate product.

3. Hydrocarbon materials can be vaporized and/or thermally cracked to produce a fuel gas, coke and a light oil product that can be sold or used as a by-product.

4. The coked solids only have to be burned as required to satisfy the plant energy requirements. Indications are that even partially combusted coked solids readily pass leachate test requirements.

5. Flue gas flows, therefore flue gas treatment requirements, are reduced to 5% to 15% of those for complete incineration (depending on hydrocarbon and water content of the feed). To thermally crack and recover one pound of hydrocarbon feed in the Processor requires approximately 700 BTU's of heat input. To completely burn one pound of a typical hydrocarbon requires 18 pounds of air and produces 19 pounds of flue gases with an approximate heat release of 18000 BTU's and an exit temperature of approximately 3500°F if the combustion gases are not cooled by heat exchange, water addition or cooling air addition.

6. The Processor can also be used as an incinerator for specific boiling range fractionator side-draw products that concentrate specific impurities. This side-draw product would be burned in the auxiliary burners to satisfy part of the fuel demand.

7. The Processor can handle feeds such as sand, gravel, clays, etc., that contain oversize materials.

8. In most applications for waste treatment, the cost per ton for processing should be significantly lower as compared to those for incineration.

9. Processing costs can be partially offset by sale of recovered oil products.

In certain instances, the Processor may be at a disadvantage to incineration. These instances could be:

1. Very small sites requiring a small unit with a design capacity less than two to three tons/hour.

2. Feeds that contain high hazardous metals content since the Processor does not materially alter or recover these solids.

3. Feeds where the produced oil cannot be used for recycling to a refinery, is not suitable for fuel, and can only be economically disposed of by incineration.

4. Feeds where the condensed water contains impurities that cannot be economically removed or neutralized.

CONCLUSION

UMATAC's recent test work, related to use of the Taciuk Processor technology for treatment of hydrocarbon-contaminated wastes and sludges, has successfully demonstrated this use of the Process and equipment. Environmental test results indicate that effluents can be "delisted" and disposed of as "safe" materials. Transportable plants, in the capacity range of 5 to 20 ton/hour feed rates, can be economically constructed and operated. High thermal efficiency, low flue gas effluent rates and the potential for recovery and sale, or reuse, of oil products, are significant advantages when compared to treatment by complete incineration. Since only fuel for the Processor is burned, there are very significant savings in sulfur removal equipment and reagent requirements when processing wastes with high sulfur contents.

ACKNOWLEDGEMENTS

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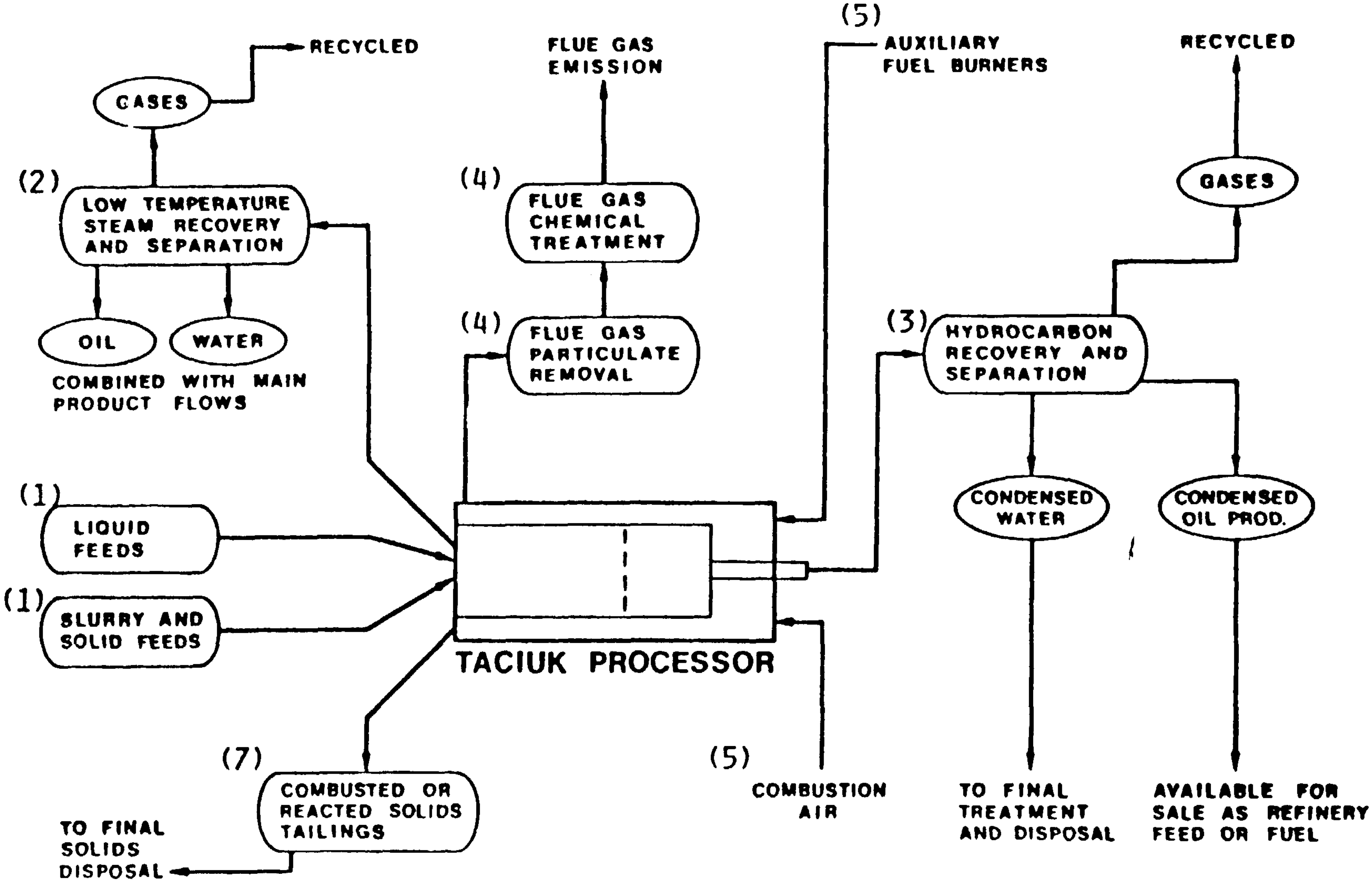
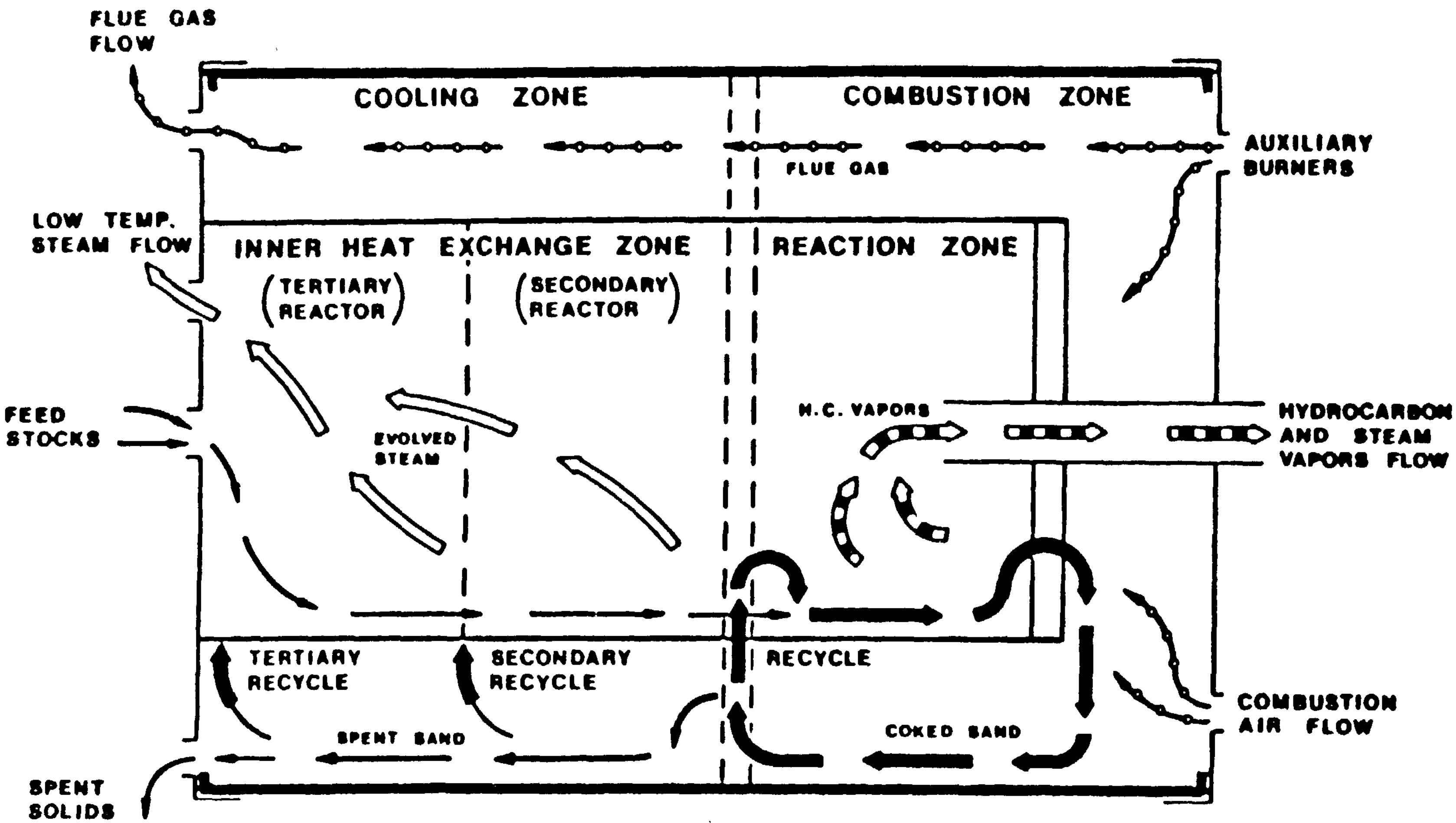


TACIUK PROCESSOR EXTERNAL SYSTEMS
FLOW DIAGRAM A



TACIUK PROCESSOR

MAJOR ZONES AND FLOW STREAMS

FLOW DIAGRAM B

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TABLE #1
BLEND FEED ANALYTICAL RESULTS
API WASTES TEST PROGRAM
(ALL VALUES IN ppm OR Mg/L UNLESS NOTED)

(NOTE - NEGATIVE SIGNS INDICATE BELOW DETECTION LIMIT
- BLANK INDICATES NONE DETECTED)

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
PROXIMATE ANALYSIS					
material density	1.00				
% ash	16.50%		NOT	98.30%	
% oil	15.50%	99.90%	DONE		NOT
% water	64.00%	0.00%		0.10%	DONE
% solids	25.10%	0.03%			
ELEMENTAL CONTENT					
carbon (% by wt.)	12.72%			0.63%	
hydrogen (% by wt.)	1.60%	NOT	NOT	0.04%	
nitrogen (% by wt.)	0.10%	DONE	DONE	0.03%	
oxygen (% by wt.)					
sulphur (% by wt.)	0.03%			0.06%	
WATER SAMPLES ONLY					
oil and grease			160		1.6
total suspended solids			90		not done
pH	8.00		8.02		7.95
total organic carbon			750		-0.2
total inorganic carbon			220		1.0
total carbon			970		1.0
phenols			90.0		0.003

NOTE: Negative values denote less than detection limit.

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
METALS AND SALT CONTENT					
aluminum	6160.0		0.39	702.00	9.75
barium	120.0		0.49	19.50	0.35
beryllium	0.2		-0.00	0.03	-0.001
boron	16.6	NOT	0.03	3.33	0.03
cadmium	-0.1	RUN	0.03	-0.10	-0.001
calcium	1224000.0	DUE TO	14.20	13000.00	360
chromium	904.0	EXTREMELY	0.21	62.70	1.20
cobalt	6.1	LOW	0.01	0.31	0.001
copper	140.0	SOLIDS	4.22	9.06	0.079
iron	7760.0	CONTENT	1.07	2000.00	0.10
lead	74.2		0.10	-0.10	-0.1
lithium	3.5		0.00	0.52	-0.001

TABLE #1 con't.

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
METALS AND SALT CONTENT					
magnesium	16000.0		4.32	1150.00	24.7
manganese	103.0		0.03	92.20	0.45
molybdenum	19.4		-0.00	2.76	0.030
nickel	83.5		0.06	3.30	0.075
potassium	596.0		0.44	107.00	1.05
silica (SIO2)	102.0		2.02	47.70	20
sodium	636.0		3.10	40.90	
strontium	496.0		0.09	33.20	0.07
titanium	39.1		0.01	15.30	-0.001
vanadium	37.0		0.01	4.97	0.001
zinc	700.0		0.05	51.10	0.39
		NOT			
antimony	0.6	RUN	0.01		
arsenic	11.6	DUE TO	0.02		
chromium (hexavalent)	0.2	EXTREMELY	-0.00		
cyanide	0.2	LOW	1.20	-0.00	0.002
fluoride	122.0	SOLIDS	4.10	1.15	3.67
lead (trace)	not done	CONTENT	not done	0.01	0.011
mercury	1.4		0.03	-0.00	-0.0001
selenium	0.0		-0.00		
phosphorus					
chloride	110.0		0.60	0.44	1.15
nitrate	-0.5		0.20	-0.01	0.04
nitrite	-0.5		-0.01	-0.01	-0.01
sulphate	8.0		39.40	10.70	11.5
bromide	1.6		0.42		
iodide	-0.1		-0.01		
thiocyanate	4.5		11.20		
thiosulphate	-0.3		51.00		
carbonate	1234000.0		49.00	not done	not done
bicarbonate	not done		927.00	not done	not done

NOTE: Negative values denote less than detection limit.

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
BP DISTRIBUTION OF ALIPHATIC ORGANICS (wt % OF SAMPLE)					
C 6-	0.10	0.06			
C 6	0.60	0.31			
C 7	1.95	1.70	NOT	-0.10	
C 8	2.62	3.49	ENOUGH		NONE
C 9	2.90	7.03	TO		DETECTED
C10	5.45	7.83	ANALYZE		
C11	5.01	7.40			
C12	4.53	7.63			

TABLE #1 con't.

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
WP DISTRIBUTION OF ALIPHATIC ORGANICS					
C13	6.22	9.50			
C14	5.62	10.64			
C15	4.69	10.35			
C16	4.04	7.23	NOT		
C17	3.56	4.79	ENOUGH		NONE
C18	3.07	4.12	TO		DETECTED
C19	2.58	3.14	ANALYZE		
C20	2.25	1.96			
C21+	40.66	12.65			
PPM of TOTAL SAMPLE	116735	999900			
BTX AROMATICS					
benzene (ppm)	157	2900	0.90	-0.10	
ethyl benzene (ppm)	590	5100	0.40	-0.10	NONE
toluene (ppm)	1000	7400	1.59	2.00	DETECTED
xlyene (ppm)	1904	15300	1.59	0.22	
HPLC SCREEN FOR PRIORITY PAHs					
acenaphthene			0.16	-0.01	
acenaphthylene			-0.01	-0.01	
anthracene			-0.01	-0.01	
benzo(a)anthracene			0.04	-0.01	
benzo(a)pyrene		NOT	-0.01	-0.01	
benzo(b)fluoranthene		POSSIBLE	-0.01	-0.01	
benzo(k)fluoranthene		TO	-0.01	-0.01	NONE
benzo(g,h,i)perylene		ANALYZE	-0.01	-0.01	DETECTED
chysene		DUE TO	-0.01	-0.01	
dibenzo(a,h)anthracene		OIL	-0.01	-0.01	
1-Methylnaphthalene		MASKING	-0.01	-0.01	
fluoranthene			0.03	-0.01	
indeno(1,2,3,c,d)pyrene			-0.01	-0.01	
naphthalene			0.02	-0.01	
phenanthrene			-0.01	-0.01	
pyrene			-0.01	-0.01	
indene				-0.01	
HPLC SCREEN FOR PHENOLS					
group 1 - benzenethiol					
4,6-dinitrophenol			-0.10		
meta-chlorocresol	-0.10			-0.10	
group 2 - meta-cresol					

TABLE #1 con't.

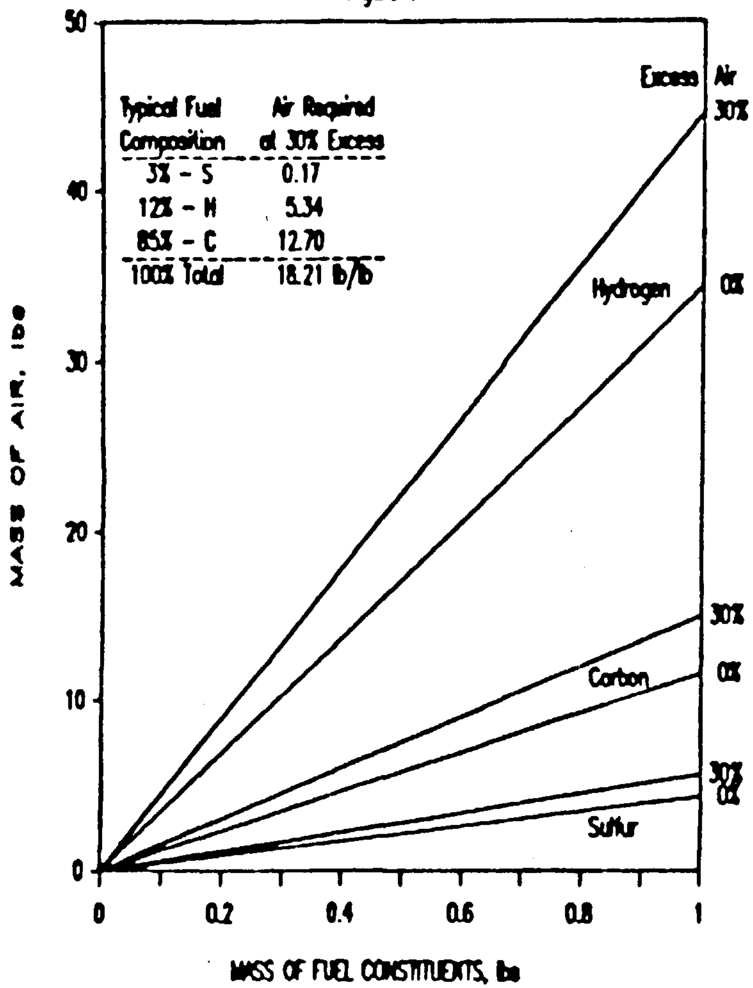
	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
HPLC SCREEN FOR PHENOLS					
ortho-cresol			45.20		
para-cresol	0.50			-0.10	
group 3 - 2-nitrophenol		NOT	0.60		
4-nitrophenol	-0.10	POSSIBLE	0.30	-0.10	
2-chlorophenol . . .	-0.10	TO	3.00	0.30	
2,4-dichlorophenol . .	0.50	ANALYZE	0.30	-0.10	NONE
2,4-dimethylphenol . .	2.30	DUE TO	-0.10	-0.10	DETECTED
ortho-chlorocresol . .	-0.10	OIL	-0.10	-0.10	
para-chlorocresol . .	-0.10	MASKING	4.00	-0.10	
pentachlorophenol . .	11.20		40.20	3.50	
phenol	7.70		-0.10	1.20	
2,4,6-trichlorophenol .	0.30		-0.10	-0.10	

NOTE: Negative values denote less than detection limit.

	BLEND FEED	PRODUCED OIL	PRODUCED WATER	COMBUSTED SOLIDS	LEACHATE
MISCELLANEOUS WATER ANALYSIS					
BOD (mg/l)			455.00		
COD (mg/l)			926.00		
silica (mg/l)			2.02		
oxygen			not done		
sulphur (mg/l)			64.00		

COMBUSTION AIR REQUIREMENTS

Figure 1



COMPARATIVE COOLING CAPACITY

Figure 2

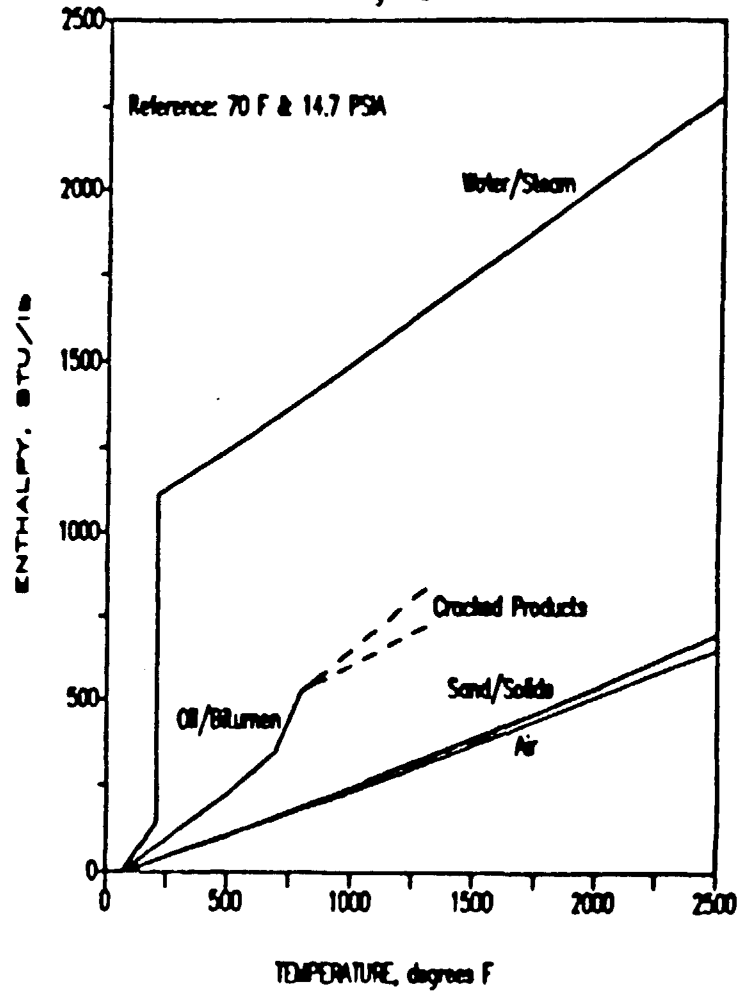


TABLE 2 - PAGE 1 — APPROXIMATE COMPARISON OF A 15 TON/HOUR WASTE PLANT USING A TACIUK PROCESSOR VERSUS AN INCINERATOR PLANT

		TACIUK PROCESSOR	INCINERATOR
Feed - T/hr		15 ton/hour	15 ton/hour
Feed Analysis (Weight %)	- Water	35%	35%
	- Hydrocarbons	50%	50%
	- Solids	10%	10%
	- Sulfur	5%	5%

MM BTU/Hour Required for Following Functions

	TACIUK PROCESSOR	INCINERATOR
Evaporate Water at 250°F	11.55 MM BTU	11.55 MM BTU
Thermally Crack Hydrocarbons at 1000°F	9.75 MM BTU	9.75 MM BTU
Heat Solids to 1000°F	.72 MM BTU	.72 MM BTU
Heat Sulfur to 1000°F	.35 MM BTU	.35 MM BTU
Heat Losses	1.20 MM BTU	1.20 MM BTU
Process Heat Required	23.75 MM BTU	Below
Internal Heat Exchange	(4.50)MM BTU	0
Heat Combustion Air to 1350°F	9.10 MM BTU	Below
Processor Heat Input	28.35 MM BTU	Below

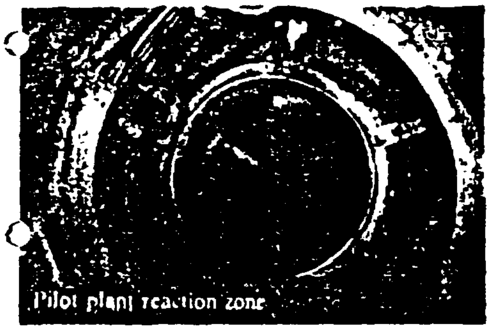
TABLE 2 - PAGE 2	TACIUK PROCESSOR	INCINERATOR
Heat Steam to 1800°F	not required	8.95 MM BTU
Heat Hydrocarbons to 1800°F	not required	7.20 MM BTU
Heat Solids to 1800°F	not required	.74 MM BTU
Heat Sulfur to 1800°F	not required	.36 MM BTU
Incinerator Heat Losses	0 MM BTU	2.50 MM BTU
Incinerator Heat Required	0 MM BTU	43.32 MM BTU
Heat Combustion Air to 1800°F	not required	32.00 MM BTU
Incinerator Heat Input	0 MM BTU	75.00 MM BTU
Fuel Consumed (at 18000 BTU/lb)	1,575 lbs/hr	4,170 lbs/hr
Hydrocarbon Products Not Consumed	part of coke	10,830 lbs/hr
Combustion Air to Combust Hydrocarbons	0 lbs/hr	195,000 lbs/hr
Additional Heat Release	0 MM BTU	195.00 MM BTU
Total BTU's Released	28.35 MM BTU	270.00 MM BTU
Additional Flue Gas - Mix Temperature	not required	3200°F
Added Cooling Air for 1800°F Exit	--	165,000 lbs/hr
Total Flue Gases - Temperature	650°F	1800°F
Total Flue Gases	31,000 lbs/hr	460,000 lbs/hr
- Steam Added	1,500 lbs/hr	25,000 lbs/hr
- Sulfur Dioxide Added	125 lbs/hr	3,000 lbs/hr

TABLE 2 - PAGE 3	TACIUK PROCESSOR	INCINERATOR
Total Flue Gas Flow	16,500 ACFM	505,000 ACFM
Comb. Zone Volume for 2 Second Residence	550 cu.ft.	16,900 cu.ft.
Combustion Zone Temperature	1400°F	1800°F
Design Gas Residence Time	6 to 10 seconds	2 seconds
Design Solids Residence Time	10 to 15 minutes	0.03 minutes
Bag House Particulate Capture (Oper.Temp)	375°F	375°F
Quench Water Addition	2,000 lbs/hr	123,000 lbs/hr
Resultant Flue Gas Flow	13,600 ACFM	270,000 ACFM
Wet Scrubber SO_2 Removal (Oper.Temp)	200°F	200°F
Quench Water Addition	1,400 lbs/hr	27,000 lbs/hr
Final Flue Gas Flow	10,500 ACFM	210,000 ACFM
Water Vapor In Final Flue Gas	5,000 lbs/hr	175,000 lbs/hr

Summary Of Process Effluents

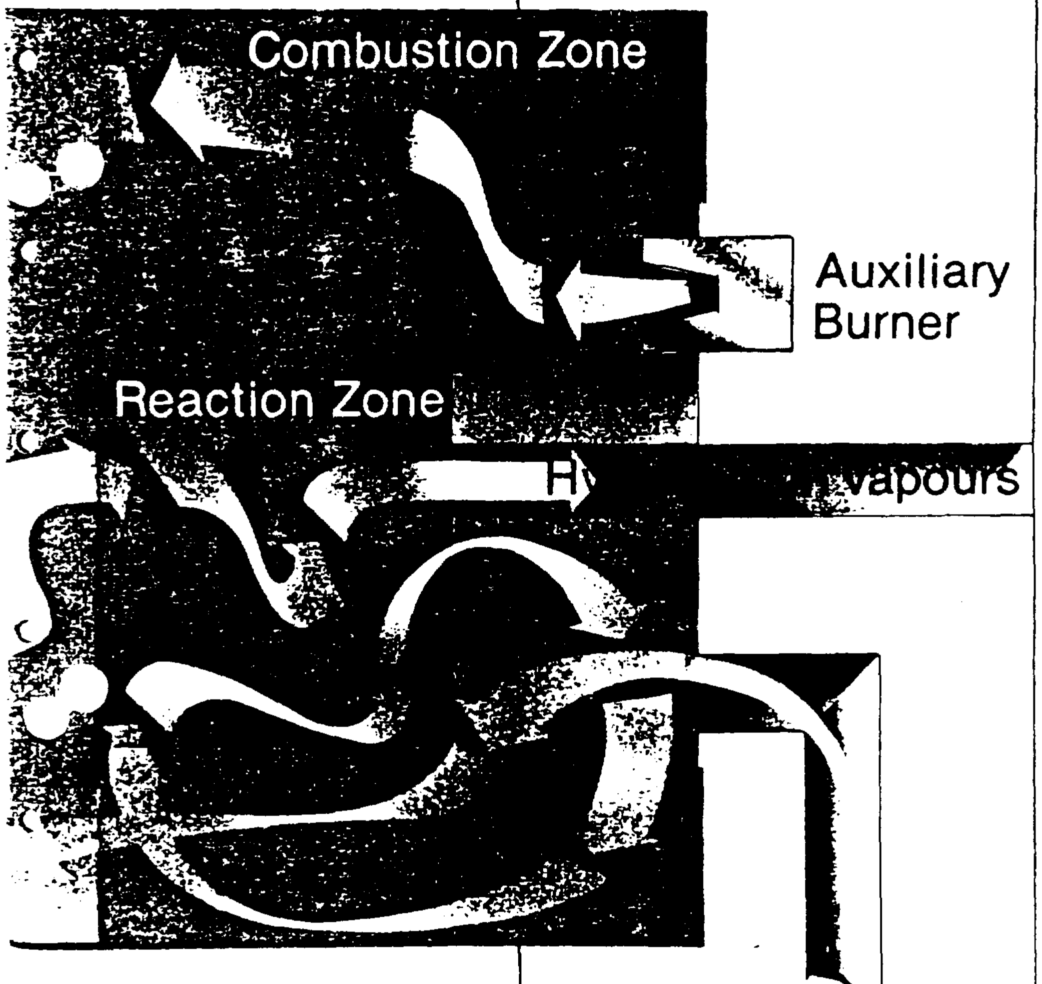
Light Oil Recovered	11,000 lbs/hr	0
Energy in Recovered Oil (at 19000 BTU/lb)	210 MM BTU	0
Solids Recovered	Ready for Disposal (Partial coke Remaining)	Contained in Wet Scrubber Slurry
Condensed Water	10,000 lbs/hr	0

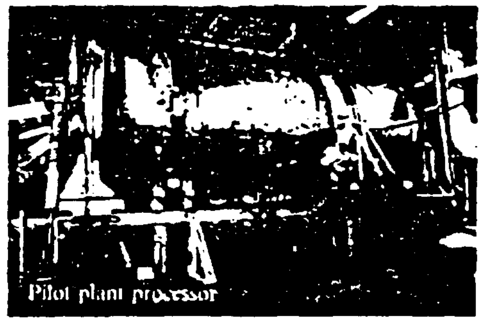
TABLE 2 - PAGE 4	TACIUK PROCESSOR	INCINERATOR
Lime Reagent Plus Sulfur	250 lbs/hr (max.)	7,000 lbs/hr
Flue Gas Discharge - Inert Gases	30,000 lbs/hr	450,000 lbs/hr
- Water Vapor	5,000 lbs/hr	175,000 lbs/hr
Total Discharge	37,000 lbs/hr	635,000 lbs/hr
Miscellaneous Data		
Heat Produced During Processing	30 MM BTU	270 MM BTU
Approximate Process Water Required	7,500 lbs/hr 15 USGPM	225,000 lbs/hr 450 USGPM
Final Slurry Treatment Required	yes	yes
Solids in Slurry	500 lbs/hr	10,000 lbs/hr
Condensed Water Final Treatment	yes for 10,000 lbs/hr	none 0
Hydrocarbon Products Recovered - Oil	35 barrels/hr	0
- Gas	0	0
- Coke	0	0



Pilot plant reaction zone

2 The preheated, dry oil sand flows into the *reaction zone* where it is intimately mixed with hot, oil-free tailings sand. The temperature of the mixture is sufficient to thermally crack the bitumen in the oil sand and vaporize the hydrocarbon products.





Pilot plant processor

3 The vaporized, cracked hydrocarbons flow out of the processor for recovery in a typical refinery system.

4 Coke formed by the cracking operation coats the inert sand. Coked sand flows into a *combustion zone* where preheated air is introduced to burn the coke to provide heat for the process. Auxiliary fuel is added to the combustion zone for trim control and start-up.

5 Part of the hot, coke-depleted tailings sand is recycled to the *reaction zone*. This recycled sand serves as a heat source for the reaction.

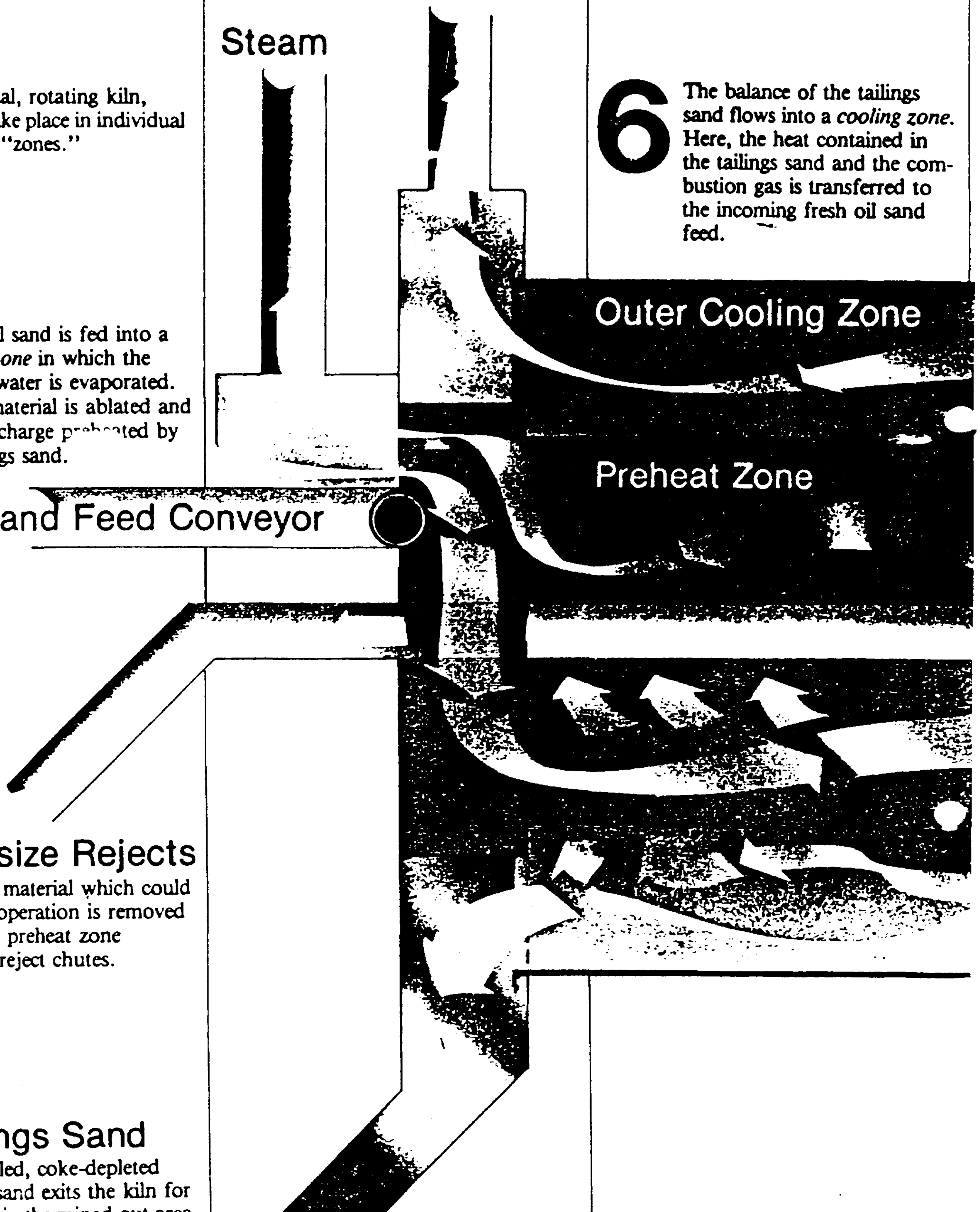
The Taciuk Processor - Internal Process Flows

Within a horizontal, rotating kiln, processing steps take place in individual compartments or "zones."

8 Flue Gases
The combustion gas flows to a flue gas treating system.

6 The balance of the tailings sand flows into a *cooling zone.* Here, the heat contained in the tailings sand and the combustion gas is transferred to the incoming fresh oil sand feed.

1 Mined oil sand is fed into a *preheat zone* in which the connate water is evaporated. Frozen material is ablated and the feed charge preheated by the tailings sand.



Oversize Rejects
Oversize material which could hamper operation is removed from the preheat zone through reject chutes.

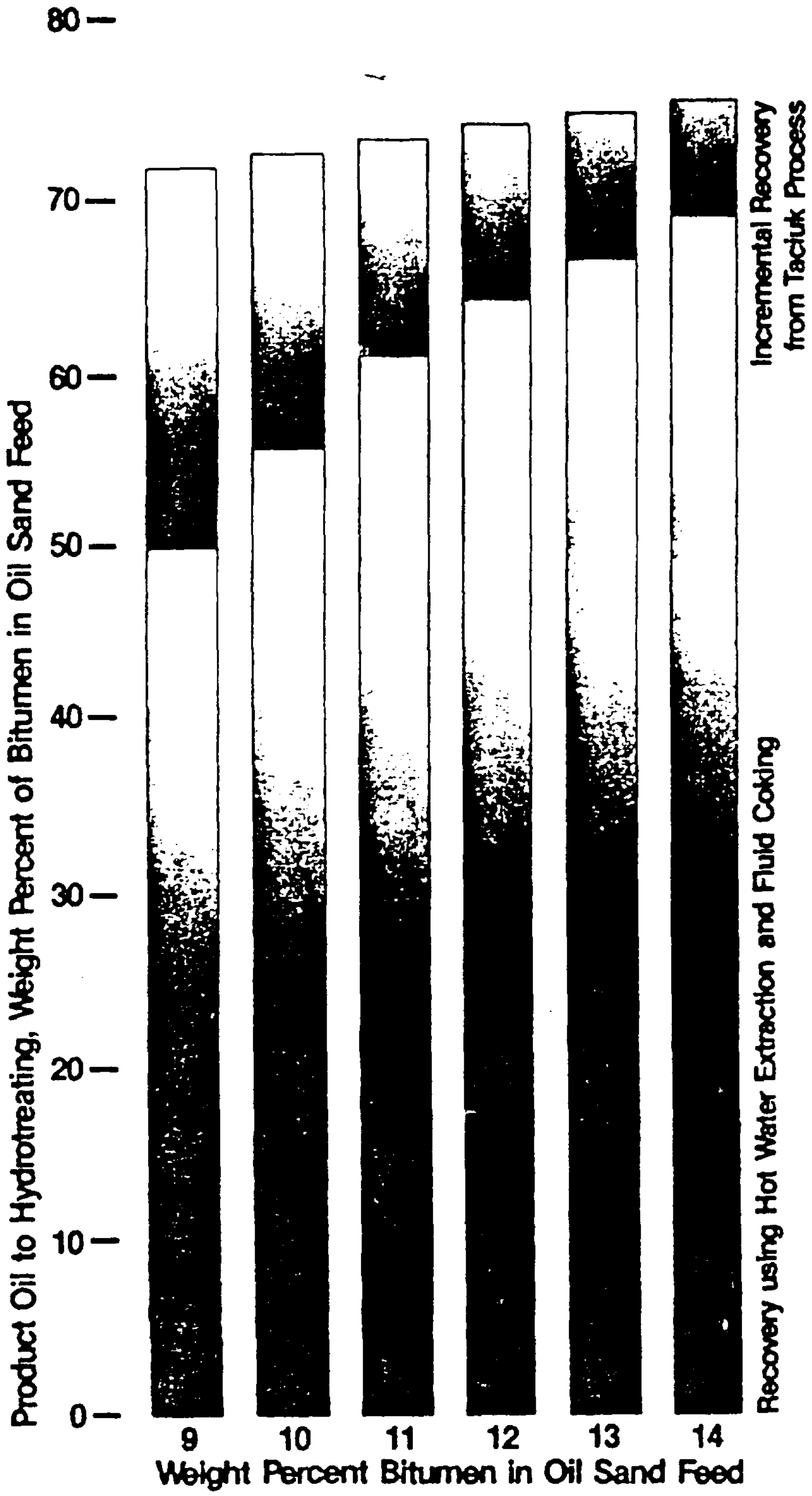
7 Tailings Sand
The cooled, coke-depleted tailings sand exits the kiln for disposal in the mined-out area.

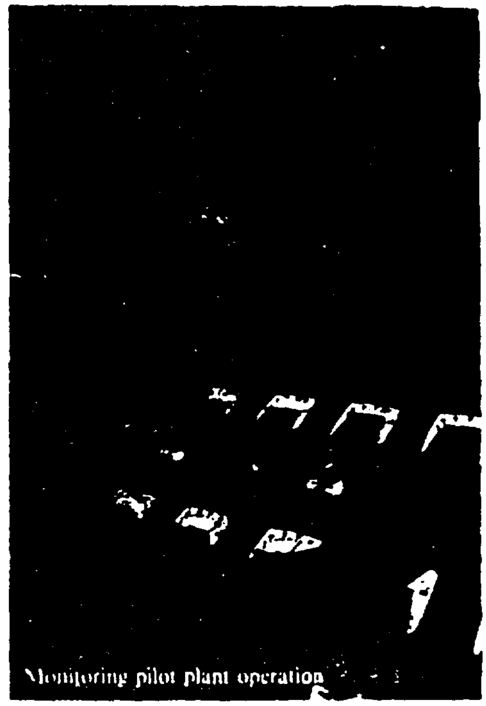
The Potential

As you can see, substantially improved oil yields are projected for oil sands plants utilizing the Taciuk Processor. Of special interest is the relative insensitivity to oil sand feed grade variations. These yield improvements are the result of a major processing difference:

The Taciuk Processor applies heat directly to the oil sands. All oil in the feed sand is subjected to reaction temperatures above 975 °F (524 °C). At these temperatures, oil must thermally crack, producing coke, light oil and off-gas. The light oil and off-gas are recovered, and most of the coke is consumed as fuel.

This process is not materially influenced by the fines (minerals less than 44 micron in size) contained in the oil sand feed.




Monitoring pilot plant operation

It is apparent that the Taciuk Process provides an effective alternative to Hot Water Extraction which relies on gravity separation to separate sand/oil/water so they may be handled separately. The fines content of oil sand feed interferes with this gravity separation and results in significant oil losses to the tailings ponds. In general, the fines content is inversely proportional to the bitumen contained in the oil sands. Increased fines content, as measured by reduced bitumen content, increases oil losses in the Hot Water Extraction Process.

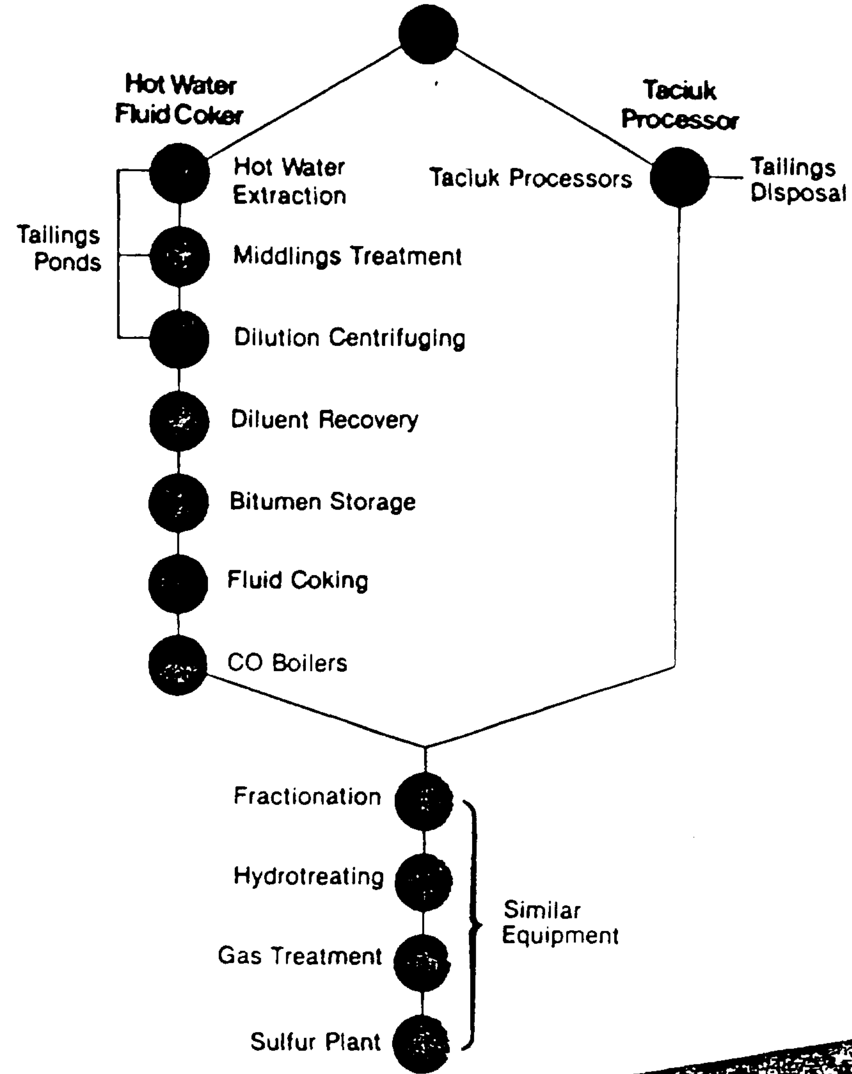
Process Advantages

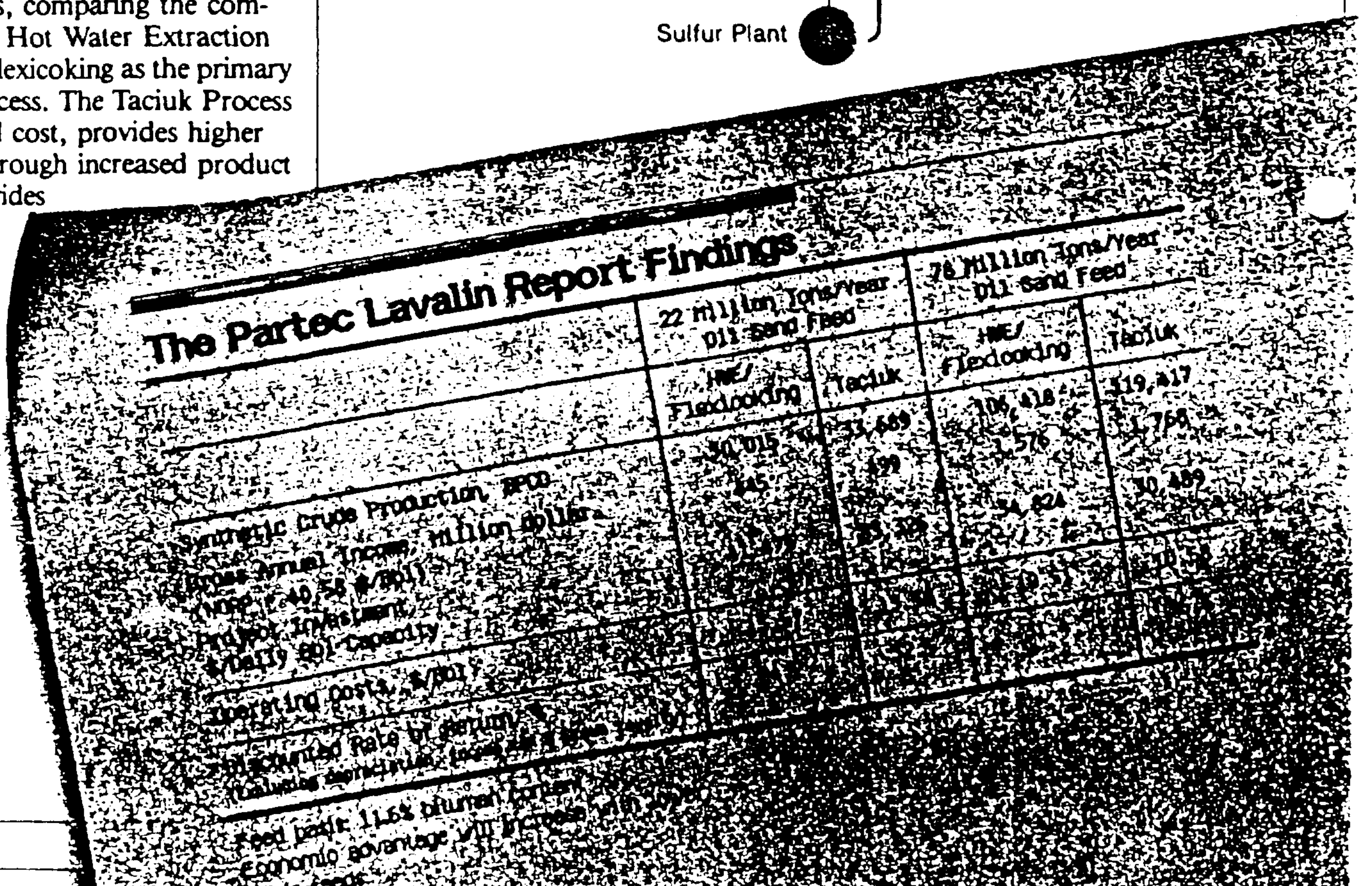
Unlike current commercial operations, the Taciuk Process combines extraction and primary upgrading processes into one process operation. The Taciuk Process offers six, distinct technical advantages:

- Consistent, high liquid hydrocarbon recovery from oil sands containing 4 to 14 per cent bitumen
- Elimination of upgrader residue
- Production of dry tailings - elimination of tailings ponds
- [illegible]imination of the need for separate extraction and primary upgrading processes
- Reduction of process water requirements
- Improvement in energy efficiency.

Technological advantages must ultimately be reflected in economic advantages. Partec Lavalin Inc., an independent consultant, has conducted a comprehensive evaluation of the Taciuk Process, comparing the commercially used Hot Water Extraction Process with Flexicoking as the primary upgrading process. The Taciuk Process reduces capital cost, provides higher revenue through increased product yield and provides an improved rate of return on total project capital investment.

Mined Oil Sand Plants Major Processing Steps





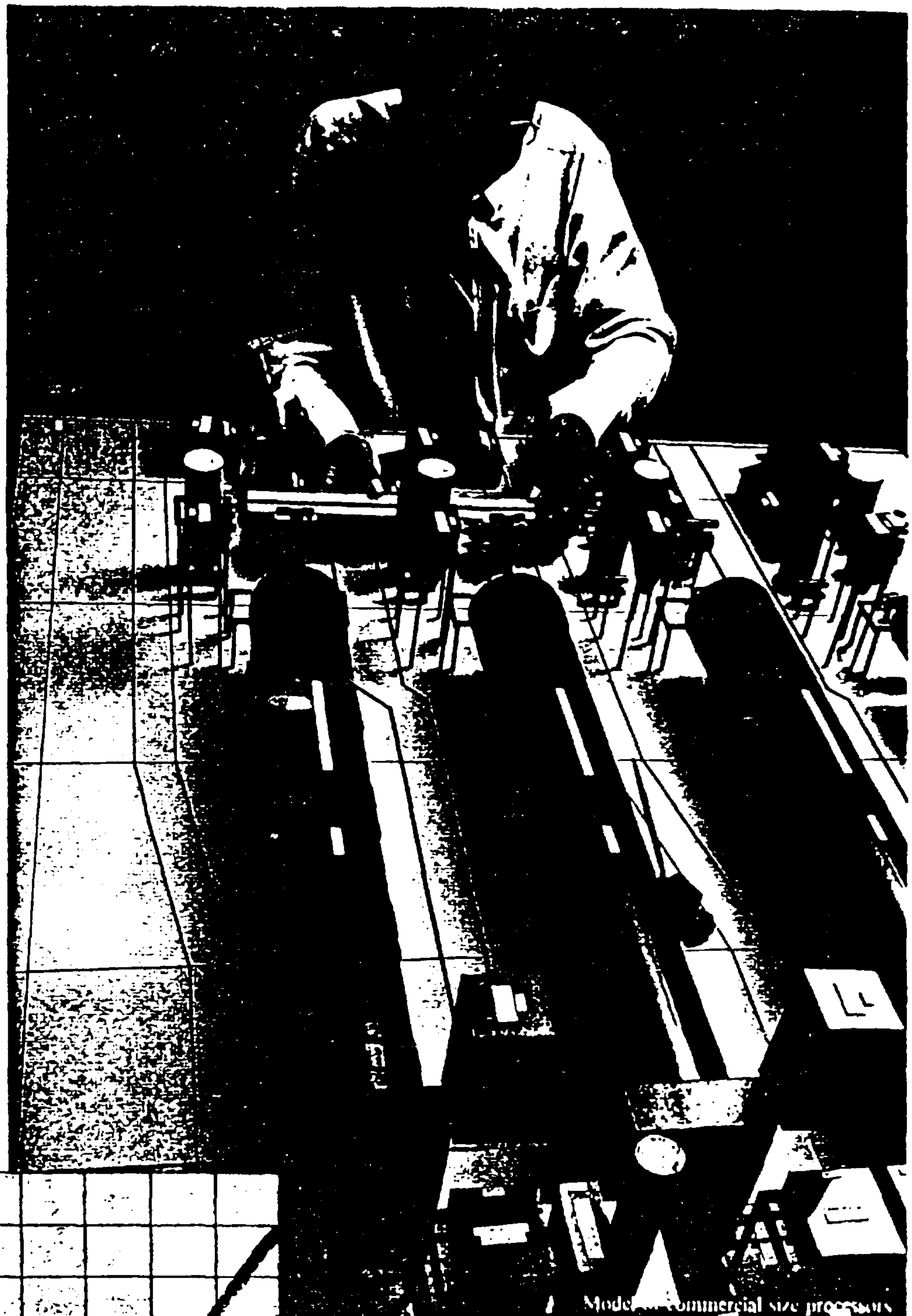
The Partec Lavalin Report Findings

	22 Million Tons/Year Oil Sand Feed		78 Million Tons/Year Oil Sand Feed	
	HWE/ Flexicoking	Taciuk	HWE/ Flexicoking	Taciuk
Synthetic Crude Production, BPCD	30,015	33,669	106,418	119,417
Gross Annual Income, Million Dollars (Note: 1 40.56 $/BBL)	445	499	1,576	1,768
Project Investment $/Daily BBL Capacity	[illegible]	[illegible]	34,824	30,489
Operating costs, $/BBL	[illegible]	[illegible]	[illegible]	[illegible]
Discounted Rate of Return, % (Including depreciation, income tax ...)	[illegible]	[illegible]	[illegible]	[illegible]

Feed basis: 11.6% bitumen content. Economic advantage will increase with [illegible] grade feeds.

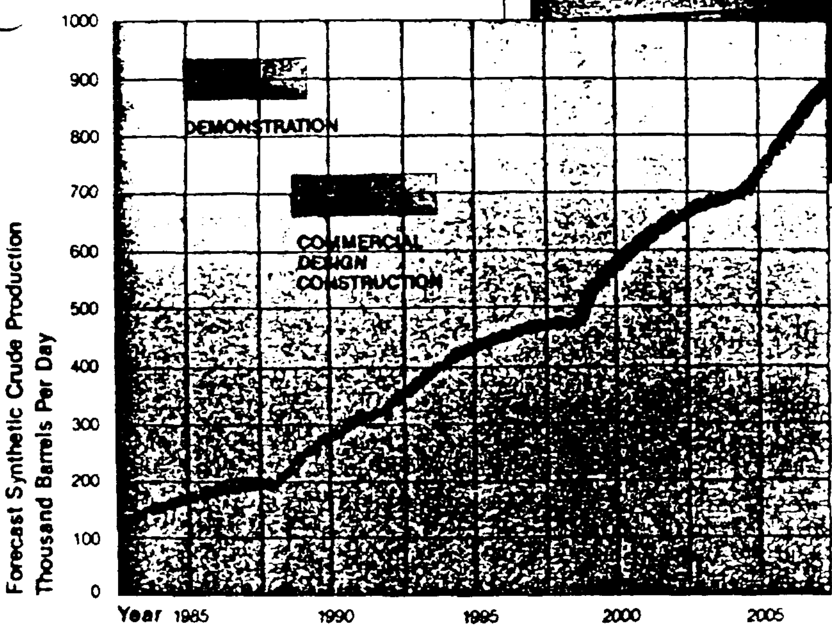
With the Demonstration facility at 100 tons/hour, scaleup from the 5 tons/hour Pilot Plant is 20:1. Scaleup to the 1000 tons/hour commercial capacity is 10:1. These scaleup ratios meet industry standards in scaling up from the Pilot Plant to the Demonstration Plant, and from the Demonstration Plant to commercial capacities.

The facility will be located on the site of the Oil Sands Demonstration Centre, south of the Syncrude Canada Ltd. mine, and will contain all the elements of a commercial Taciuk Processor.



Model of commercial size processors

The Alberta Energy Resources Conservation Board forecasts a significant expansion in synthetic crude oil production beginning about 1988. In order to have the Taciuk Process available as a candidate process for the forecasted increase, the Process must be demonstrated now.



The Partners

Over the next four years, the project will move forward with a two-year detailed design and construction period, followed by a two-year operation period. An execution plan, project schedule, and capital and operating cost estimates have been developed on this basis. The total estimated cost of the program is $74.3 million.

AOSTRA has approved funding for 50 per cent of the Demonstration Plant phase. In keeping with our mandate to involve industry in the development of new technology, we are ready to be joined on an equity basis by industry members.

Based on the results of the pilot project and the commercial potential of the process, we are now confident in offering you the opportunity to become a partner in progress on the Taciuk Project.

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